

Interpretation of Lu-Hf garnet geochronology by investigation of HREE zoning profiles

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Garnets are well suited for Lu-Hf and Sm-Nd geochronology, and a growing number of studies now focus on the Lu-Hf system for evaluating the evolution of different types of metamorphic rocks, because of the difference in the ages obtained by the two isotope systems (Lu-Hf dating early, Sm-Nd dating late growth). However, the interpretation of ages obtained for garnets by the Lu-Hf system is not always straightforward due to the ambiguity in the explanation of observed sharp Lu-peaks in garnet cores. Garnet strongly controls the Lu (and other HREE) budget of many metamorphic rocks, and also more often than not inherit information obtained during pro- and retrograde growth through enrichment of Lu & HREE in early formed cores. The mere occurrence of sharp Lu peaks in garnet cores in rocks of (ultra)high-pressure and high-temperature conditions indicates a resistance to metamorphic resetting, therefore attesting to the suitability of Lu-Hf garnet geochronology for complex metamorphic rocks.

In this study we concentrated on the Lu & HREE distribution in garnets from different metamorphic rocks to evaluate the modes of incorporation during growth and also processes of resetting of these growth profiles. We also investigated the impact of these growth profiles on the Lu and Hf isotopic composition of different garnet zones, trying to determine growth rates of garnets, and how this will affect the Lu-Hf ages obtained for bulk-garnet separates. This includes both a model approach to assess the influence of several garnet growth events on bulk garnet ages, as well as the “in-situ” (small portions of a garnet zone cut-out/drilled-out) measurement of the isotopic composition in suitable garnet grains.

As more garnets from different types of rocks are being analysed for their potential Lu growth profiles our understanding of how to interpret the obtained ages is improving, especially when we compare Lu-Hf ages with geochronology of other minerals based on other isotope systems. Hence a larger database will shed light on the discussion of e.g. which mineral best yields an age estimate for prograde, peak and retrograde conditions in a metamorphic rock.

Experimental study on the pseudobinary H₂O+NaAlSi₃O₈ at 600–800 °C and to 2.5 GPa

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There are still uncertainties in phase relations in the high-temperature portion of P-T diagrams for H₂O+NaAlSi₃O₈ (e.g., [1]). Dissolution of albite in H₂O is usually considered to be congruent or nearly congruent [2], although many experiments showed formation of the aluminous solids paragonite (e.g., at 500–650 °C, 0.5–0.9 GPa [2], at 500 °C, 0.2–0.7 GPa and 600 °C, 0.4–0.8 GPa [3], and at 700 °C, 1–1.5 GPa [4]) and corundum (e.g., at 800 °C, 0.7–2 GPa [4]). However, some of these P-T conditions intersect that of the critical curve [5] along which no solid phase can be present. For information to resolve this conflict, we conducted experiments on several pseudobinary mixtures between 39 and 54 wt% NaAlSi₃O₈, i.e., near the critical composition [5]. The system was studied by optical observation and Raman spectroscopy using a hydrothermal diamond-anvil cell [6]. Synthetic zircon was used as Raman spectroscopic pressure sensor [7].

At the start of each run, the assemblage silicate glass and aqueous fluid was heated to 600 °C. Then, the resulting melt and aqueous fluid were held at this temperature until a solid had formed. Jadeite grew rapidly at P ≥ 2 GPa. In experiments at pressures to 1.06 GPa, albite nucleated within a minute to a few hours. Paragonite formed at 1.64 GPa in an experiment with 54 wt% NaAlSi₃O₈ and at 1.09 GPa at 39 wt% NaAlSi₃O₈. Upon heating, paragonite was still present at and above the temperature of homogenization of silicate melt and aqueous fluid to a single fluid phase, whereas albite always showed the expected melting at temperatures less than that of melt and aqueous fluid homogenization.

Our data indicate that the high-pressure portion of the critical curve [5] is a metastable extension at T < 760 °C, at which paragonite is stable. Furthermore, the formation of a substantial fraction of paragonite at intermediate bulk NaAlSi₃O₈ concentrations implies that the aqueous fluid must have a peralkaline composition, which in turn enhances the solubility of high field strength elements. The obtained data for the P-T location of the critical curve based on the determined isochores are close to or at slightly higher pressure than those reported in ref. [5].

[1] Hayden & Manning (2011) *Chem. Geol.* **284**, 74-81. [2] Shmulovich *et al.* (2001) *Contrib. Mineral. Petrol.* **141**, 95-108. [3] Davis (1972) PhD diss., Penn. State Univ. [4] Antignano & Manning (2008) *Chem. Geol.* **255**, 283-293. [5] Shen & Keppler (1997) *Nature* **385**, 710-712. [6] Bassett *et al.* (1993) *Rev. Sci. Instrum.* **64**, 2340-2345. [7] Schmidt *et al.* (2011) *Min. Mag.* **75** (3), 1819.